TITLE: **CATALYTIC GASIFICATION OF COAL USING EUTECTIC SALT MIXTURES**

PIs: **Yaw D. Yeboah and Yong Xu**

INSTITUTION: **Department of Engineering**
Clark Atlanta University (CAU)
Atlanta, Georgia 30314
(404) 880-6169

SUBCONTRACTORS: **Atul Sheth, The University of Tennessee Space Institute (UTSI)**
Pradeep Agrawal, Georgia Institute of Technology

STUDENTS: **Pamela Reid and Tamara Gray (CAU)**
Anuradha Godavarty (UTSI)
Megan Czarny (Georgia Tech)

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ABSTRACT

OBJECTIVE

The project, *Catalytic Gasification of Coal Using Eutectic Salt Mixtures*, is being conducted jointly by Clark Atlanta University (CAU), the University of Tennessee Space Institute (UTSI) and the Georgia Institute of Technology (Georgia Tech). The aims of the project are to:

- Identify appropriate eutectic salt mixture catalysts for the gasification of Illinois #6 coal;
- Evaluate various impregnation or catalyst addition methods to improve catalyst dispersion;
- Evaluate effects of major process variables (e.g., temperature, system pressure, etc) on coal gasification;
- Evaluate the recovery, regeneration and recycle of the spent catalysts in a bench-scale fixed bed reactor; and
- Conduct thorough analysis and modeling of the gasification process to provide a better understanding of the fundamental mechanisms and kinetics of the process.

ACCOMPLISHMENTS TO DATE

Several single salt catalysts and binary and ternary eutectic catalysts were investigated at CAU. Physical mixing and incipient wetness methods were investigated as catalyst addition techniques. Gasification was carried out using a TGA at CAU and a fixed-bed

reactor at UTSI. The results showed better gasification activity in the presence of the catalysts tested. The order of catalytic activity of eight single salt catalysts tested was:

$Li_2CO_3 > Cs_2CO_3 > CsNO_3 > KNO_3 > K_2CO_3 > K_2SO_4 > Na_2CO_3 > CaSO_4$

The eutectic salt studies showed clear agreement between the melting points of the prepared eutectics and reported literature values. The order of catalytic activity observed was ternary > binary > single. The incipient wetness method was found to give better results than physical mixing technique for the soluble catalysts. Also, catalyst preparation conditions such as catalyst loading, drying time and temperature were found to influence the gasification rate.

Based on the Clark Atlanta University studies, the project team selected the 43.5% Li_2CO_3-31.5% Na_2CO_3-25% K_2CO_3 ternary eutectic and the 29% Na_2CO_3-71% K_2CO_3 binary eutectic for the fixed-bed studies at UTSI. The ternary and binary eutectic catalysts were added to the raw coal by physical mixing and pyrolyzed at 1350^0 F for 3 hours. The pyrolyzed char was crushed and sieved to get a feed to the reactor whose particle size varied between 30 mesh and 100 mesh. The char was gasified at various conditions of temperature, pressure, catalyst weight percent, and molar ratio of steam to char. Temperature was found to have a significant effect on the rate of gasification of coal. The rate of gasification increased with temperature up to 1350^0 F, and marginally increased thereafter. Pressure did not have much effect on the gasification rate. The catalyst loading increased the gasification rate up to about 10 to 15 wt% of catalyst added to the coal. Upon further increasing the catalyst amount to 20 wt% and above, there was no significant rise in gasification rate. The characterization results of Georgia Tech are very preliminary and inconclusive and will be reported at a later date.

The eutectic salts were found to be highly insoluble in aqueous medium. As a result, the technique of adding the eutectic catalyst to the raw coal was found to be better than using wet methods. In addition, eutectic catalysts added to the coal yielded better gasification rates than rates obtained by mixing the individual salts in the eutectic ratio with the coal. The results obtained so far, especially with the eutectic catalysts, are very significant since the use of the low melting eutectics will reduce the severity of gasification processes.

PLANS FOR THE COMING YEAR

- Assess agglomeration tendency of the catalyzed coal;
- Evaluate the recovery, regeneraton and recycle of the spent catalysts;
- Conduct thorough analysis and modeling of the gasification process to provide better understanding of the fundamental mechanisms and kinetics of the process;
- The bench scale fixed-bed gasification reactor studies will concentrate on the catalyst systems 50% Li_2CO_3-29% Na_2CO_3-21% Rb_2CO_3 and 39% Li_2CO_3-38.5% Na_2CO_3-22.5% Rb_2CO_3.
- Characterization of the catalysts, and coal/catalyst samples and products will be undertaken to assess catalyst dispersion and the effectiveness of the catalysts and impregnation/addition methods.

ARTICLES, PRESENTATIONS, AND STUDENT SUPPORT

Conference Presentations

- Yeboah, Y. D., Y. Xu, A. Sheth and P. Agrawal, "Catalytic Gasification of Coal Using Eutectic Salt Mixtures", presented at 7th Annual Historically Black Colleges and Universities and Other Minority Institutions Symposium, Miami, Florida, March 1999

Students Supported under this Grant

- Pamela Reid and Tamara Gray, undergraduate students in chemical engineering, Clark Atlanta University (CAU)
- Anuradha Godavarty, graduate student in chemical engineering, The University of Tennessee Space Institute (UTSI)
- Megan Czarny, undergraduate student in chemical engineering, Georgia Institute of Technology (Georgia Tech)